REMARKS

Applicant would like to thank the Examiner for the careful consideration given the present application. The application has been carefully reviewed in light of the Office action, and amended as necessary to more clearly and particularly describe the subject matter which applicant regards as the invention.

OBJECTIONS TO THE SPECIFICATION

The Abstract of the Disclosure and the Specification have been objected to because the spacing of the words was said to be too close together. In response thereto, a new Abstract is submitted with the present amendment, and a Substitute Specification is attached herewith. A marked up copy of the Substitute Specification is provided, as required, although no changes have been made to the content of the specification. No new matter has been added by the Substitute Specification. Reconsideration and withdrawal of these objections is respectfully requested.

OBJECTIONS TO THE DRAWINGS

The drawings had been objected to as allegedly failing to show certain structural details, as indicated in the outstanding Office Action. The Examiner had required corrected drawing sheets in reply to the Office Action to avoid abandonment of the application. However, it is respectfully submitted that corrected drawings are not required. The drawing objection had been made in conjunction

with a corresponding rejection under Section 112, first paragraph, the response to which is hereinbelow. Therefore, a discussion of the drawing objection will be made in conjunction with the corresponding 112 rejection.

THE REJECTIONS UNDER 35 U.S.C. § 112

Claims 1-16 had been rejection under Section 112, first paragraph, as allegedly failing to comply with the enablement requirement. This rejection is respectfully traversed.

The Examiner states that the following claim limitations are not enabled by the specification:

From claim 6 – "a sampling circuit for sampling an amplitude of one of said first and second phase-shifted signals at a timing when the other has a phase angle of a certain value;"
From claim 7 – "a pulse generator for detecting a zero cross point of said the other of first and second phase-shifted signals to generate a sampling pulse supplied at each zero cross point to said sampling circuit.

The Examiner states that these limitations are not enabled in the specification, that it is not clear as currently defined how the sampling circuit and the pulse generator perform their associated functions, and also that claims 1-5 have similar problems. This assertion is not well taken. Support for these limitations can be found in the passage at e.g. paragraph [0028] of the Substitute Specification.

As such, it is respectfully submitted that the "sampling circuit" and "pulse generator for detecting a zero cross point" limitations as presently recited herewith are basic, key elements regarded as conventional features in the art of digital signal processing. One skilled in the art would thus understand the structure and operation

of a sampling circuit and pulse generator without an exhaustive description. It is therefore respectfully submitted that the present disclosure does in fact contain sufficient information regarding the structure and operation of the sampling circuit and pulse generator so as to enable one skilled in the pertinent art to practice the invention without undue or unreasonable experimentation. Therefore, the present disclosure satisfies the Test of Enablement as set forth in MPEP 2164.01. Reconsideration and withdrawal of these grounds of rejection is respectfully requested.

As to the drawing objection as noted above, it is respectfully submitted that the present drawings do in fact depict the invention in terms sufficient to enable the person of skill in the art to practice the invention. It has been shown above that "sampling circuit" and the "pulse generator" are conventional features in the art of digital signal processing. As stated in 37 CFR 1.83(a), "...conventional features disclosed in the description and claims, where their detailed illustration is not essential for a proper understanding of the invention, should be illustrated in the drawing in the form of a graphical drawing symbol or a labeled representation (e.g., a labeled rectangular box)." The present drawings comply with the requirement of Rule 83(a), and as such it is respectfully submitted that the drawing objection is without basis. Reconsideration and withdrawal of this objection is therefore respectfully requested.

Claims 1-10 had been rejection under Section 112, second paragraph, as allegedly being indefinite. This rejection is respectfully traversed, particularly as applied to the claims as presently amended.

Claim 6 has been amended to clarify the language upon which the Examiner

bases the rejection. Reconsideration and withdrawal of this rejection is respectfully requested.

In connection with claim 1, it is respectfully submitted that the phrase "passing the alternating signal through the first and second all pass filters to generate a first and a second phase-shifted signals with a phase delay difference 90 degree therebetween within said frequency range" is not indefinite. In paragraph [0026] of the Substitute Specification, it is recited that the circuit 11 and 12 is constructed as shown in Fig. 2, and 90 degree phases shifted signals S1 and S2 are generated by setting the time constants (Rx1, Cx1), (Rx2, Cx2). It is therefore respectfully submitted that the claim language is in fact sufficiently clear so that one skilled in the art could understand the invention. Reconsideration and withdrawal of this rejection is respectfully requested.

THE INVENTION

As found in the present claims and disclosure, the present invention provides a method and apparatus of detecting the amplitude of an alternating signal in the form of a sinusoidal wave having a period fluctuation within a certain fluctuant range together with an amplitude fluctuation. The method and apparatus includes first and second all pass filters having phase shift characteristics set to cause a phase delay difference of 90° therebetween on signal transmission within a frequency range corresponding to the fluctuant range of the period. The alternating signal is passed through the first and second all pass filters to generate first and second phase-shifted signals with a phase delay difference of 90° therebetween within the

frequency range. The amplitude of one of the first and second phase-shifted signals is sampled at a predetermined timing when the other has a phase angle of a predetermined value. This arrangement is different than the prior art relied upon by the Examiner.

THE REJECTIONS UNDER 35 U.S.C. § 102

Claims 1, 2 and 6 had been rejected under Section 102(b) as being anticipated by Mortensen et al. This rejection is respectfully traversed.

Mortensen et al. is directed to a peak detector employing an integrator, a DC tracking circuit and a zero-crossing detection circuit for producing a logic signal indicating a peak in an input voltage signal. The Examiner reads the integrator 80 and the DC tracking circuit 82 of Mortensen et al. onto the present phase revising circuit including a first and a second all pass filters. The Examiner suggests that an alternating signal passed through elements 80 and 82 would generate first and second phase-shifted signals with a phase delay difference of 90 degrees therebetween, within a frequency range corresponding to said fluctuant range of said period.

However, the Examiner is mistaken in interpreting Mortensen et al. in this manner. In the passage cited by the Examiner, col. 1, lines 1-45, Mortensen et al. discloses that "the integrator 80 introduces a -90 degree phase shift to its output signal with respect to the input signal 10…." However, this passage goes on to state that the integrator 80 "additionally acts as a bandpass filter to attenuate low frequency and high frequency noise accompanying the input signal 10." Thus, it is

clear that that component <u>cannot</u> be read onto an "all pass filter" as recited in the present claims.

It is further noted that the DC tracking circuit 82 disclosed by Mortensen et al. merely "tracks the DC component and any low frequency noise component of output of the integrator output signal," i.e. a -90 degree shifted signal, and "provides an output level related to these components" (see col. 3, lines 21-23). It should be clear from this disclosure that this signal output from Mortensen et al.'s DC tracking circuit 82 merely includes a DC component and a low frequency noise component. Therefore, this signal <u>cannot</u> be a signal shifted 90 degrees to the output signal of the integrator 80. Thus, it should be clear that the Mortensen et al. reference <u>teaches away</u> from the present claims. In any event, Mortensen et al. cannot be relied upon to show "a phase revising circuit including a first and a second all pass filters for changing said alternating signal to a first and a second phase-shifted signals with a phase delay difference of 90 degrees therebetween within a frequency range corresponding to said fluctuant range of said period" as required by the present independent claims.

The Examiner further states that Mortensen et al. discloses "a sampling circuit (82, 84) for sampling an amplitude of one of the first and second phase-shifted signals at a timing when the other has a phase angle of a certain value." However, is respectfully submitted that the DC tracking circuit 82 and the zero-crossing detection circuit 84 of Mortensen et al. do not correspond to a "sampling circuit" as recited in claim 1. It has been shown above that the DC tracking circuit 82 tracks a DC component and a low frequency noise component. This element does not detect amplitude of the output signal from the integrator 80.

Thus, Mortensen et al. simply cannot be relied upon to show "first and second phase-shifted signals with a phase delay difference of 90 degrees," as required by the independent claims. And further, there is simply no disclose or suggestion in Mortensen et al. that the zero-crossing detection circuit 84 could be construed as a circuit "for sampling an amplitude of one of said first and second phase-shifted signals," as required by the independent claims. Therefore, it should be clear that in this respect also, the Mortensen et al. reference teaches away from the present claims.

In view of the above, it is respectfully submitted that significant differences have been shown between the Mortensen et al. reference and the invention as recited in the present independent claims. Therefore, Mortensen et al. fails to disclose every feature of the invention as is required in order to satisfy the requirements for anticipation as set forth in accordance with Section 102 (see MPEP 706.02). Reconsideration and withdrawal of these grounds of rejection is therefore respectfully requested.

Dependent claims 2, 5 and 10 had been rejected under either Section 102(b) or Section 103(a) as being unpatentable over Mortensen et al. The present dependent claims recite additional inventive features that are also not disclosed by the Mortensen et al. reference. Notwithstanding, it is respectfully submitted that the present dependent claims are allowable for at least the same reasons as the independent claims, as stated hereinabove. Therefore, reconsideration and withdrawal of these rejections are also respectfully requested.

In light of the foregoing, it is respectfully submitted that the present application is in a condition for allowance and notice to that effect is hereby requested. If it is

determined that the application is not in a condition for allowance, the Examiner is invited to initiate a telephone interview with the undersigned to expedite prosecution of the present application.

If there are any additional fees resulting from this communication, please charge same to our Deposit Account No. 18-0160, our Order No. KIS-12595.

Respectfully submitted,

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AMPLITUDE-DETECTING METHOD AND CIRCUIT

BACKGROUND OF THE INVENTION

Field of the Invention

[0001]   The present invention relates to an amplitude-detecting circuit usefully applicable in extraction of amplitude values from AC signals with jitters in the periods, such as detected signals from various instrumentation sensors, for example, a touch signal probe driven by a piezoelectric element, an electrostatic capacitance gap sensor, and the like.

Description of Related Art

[0002]   As an instrumentation sensor for use in shape measurement of a mechanical structure, for example, a touch signal probe driven by a piezoelectric element is known as shown in Fig. 6. A stylus 71 has a spherical contact 73 attached at the tip and a balancer 74 at the rear end. A stylus holder 72 holds the stylus 71 approximately at the center of the length. A piezoelectric element 75 is attached approximately at the center of the stylus 71 to impart vibrations on the stylus 71. The piezoelectric element 75 has a vibrating electrode 75a to which a driving signal is applied from a driver 78 and a detecting electrode 75b from which a mechanical-electrical converted signal is detected by a detector 76. The detector 76 positively feeds an output signal back to the driver 78. This feedback control allows the piezoelectric element 75 to be excited in a resonance state at a certain frequency.

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The signal detected at the detecting electrode 75b is a sine wave alternating signal in the form of an amplitude-modulated carrier (vibrating signal), of which amplitude and frequency vary when the contact 73 touches a work to be measured. A signal processor 77 is employed to check the amplitude of the signal obtained from the detector 76 in order to detect the touch.

[0003]   The detected signal from the touch signal probe contains jitters in the amplitude as well as in the period influenced from non-linearity of the piezoelectric element, interference among many vibration modes caused from a complicated structure, disturbances and so forth. The frequency of the detected signal is in the proximity of the frequency of the vibrating sinusiodal wave signal but fluctuates within a certain range below and above the vibrating frequency. This is disadvantageous when the amplitude of the detected signal must be detected fast or with no time delay, and with a high precision.

[0004]   A well-known conventional sampling system with a constant sampling period can be employed to detect an amplitude peak value of the signal detected by the above touch signal probe. This sampling system is possible to perform a high accurate detection when the period of the detected signal is constant but causes errors in amplitude value detection in response to a period fluctuation of the detected signal when the period is not constant. In general, the detected value varies in response to a period of the vibrating frequency.

[0005]   There is a method of rectifying full waves a detected signal then passing it through a low pass filter to remove ripples. This method is often employed to extract an amplitude value of an amplitude-modulated signal but has a large time delay on amplitude extraction due to a time constant of the low pass filter. Therefore, it can not be employed in a feedback control system for real-time constant-value controlling

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of an amplitude value that varies time to time.

[0006]   Recently, in a remarkable digital processing system, all detected

information is fast sampled, then A/D converted, and a mass digital data thus

obtained is stored in a mass memory for later FFT analysis and filtering. Such the .

processing system can detect an amplitude value with high accuracy per period

component of the detected signal while it is complicated and expensive. In addition,

the FFT processing for the mass digital data requires a long time. Accordingly, the

above processing system is effective only for an audio system and an instrumental

system, of one-directional information transmission type, which are sufficient post-

processing detected data. To the contrary, it is not applicable as such to an

automatic control system that essentially requires a real time processing to feedback

control the amplitude value varying in time to time as described above.

SUMMARY OF THE INVENTION

[0007]   The present invention has been made in consideration of the above

situation and accordingly has an object to provide a method and circuit capable of

detecting an amplitude of an alternating signal in the form of a sine wave having

fluctuations in a period and amplitude with a high accuracy and a slight time delay.

[0008]   The present invention provides a method of detecting an amplitude of an

alternating signal in the form of a sinusoidal wave having a period fluctuation within a

certain fluctuant range together with an amplitude fluctuation. The method comprises

preparing a first and a second all pass filters having phase shift characteristics set to

cause a phase delay difference of 90° therebetween on signal transmission within a

frequency range corresponding to the fluctuant range of the period; passing the

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alternating signal through the first and second all pass filters to generate a first and a second phase-shifted signals with a phase delay difference of 90° therebetween within the frequency range; and sampling an amplitude of one of the first and second phase-shifted signals at a timing when the other has a phase angle of a certain value.

[0009]   The present invention also provides a circuit for detecting an amplitude of an alternating signal in the form of a sinusoidal wave having a period fluctuation within a certain fluctuant range together with an amplitude fluctuation. The circuit has a phase revising circuit including a first and a second all pass filters with 90° phase-shifted different frequencies for passing the alternating signal through the first and second all pass filters to generate a first and a second phase-shifted signals with a phase delay difference of 90° therebetween within a frequency range corresponding to the fluctuant range of the period; and a sampling circuit for sampling an amplitude of one of the first and second phase-shifted signals at a timing when the other has a phase angle of a certain value.

[0010]   According to the present invention, an amplitude of an alternating signal can be detected at sampling timings variable in response to the period fluctuation of the alternating signal. Therefore, the detection of the amplitude value can be performed with a high accuracy and a slight time delay without affected from jitters on the period of the alternating signal.

[0011]   Other features and advantages of the invention will be apparent from the following description of the preferred embodiments thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

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[0012]   The present invention will be more fully understood from the following

detailed description with reference to the accompanying drawings in which:

[0013]   Fig. 1 is a block diagram showing an amplitude-detecting circuit according

to an embodiment of the present invention;

[0014]   Fig. 2 is a circuit diagram showing all pass filters in the same embodiment;

[0015]   Fig. 3 shows phase-shift characteristics of the all pass filters;

[0016]   Fig. 4 shows operative waveforms of the amplitude-detecting circuit of Fig.

1;

[0017]   Fig. 5 is a block diagram showing an amplitude-detecting circuit according

to another embodiment; and

[0018]   Fig. 6 shows an arrangement of a touch signal probe.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0019]   The principle of amplitude detection according to the present invention is

described prior to the description of embodiments. An alternating signal S, which is

subjected to amplitude extraction, is represented with an amplitude A, period T and

phase P by the following equation (1) :

$$S = A\sin(2\pi t/T + P) \qquad\qquad \dots (1)$$

[0020]   The AC signal of the equation (1) is passed through two all pass filters with

different center frequencies for phase shifting. The center frequency is defined as a

frequency at which 90° phase-shift is obtained. The two all pass filters are assumed

to generate two phase-shifted signals S1 and S2 that have a phase difference of 90°

therebetween within a frequency range corresponding to a fluctuant range of the

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periods of the AC signal S. The signals S1 and S2 are represented by the following equations (2) and (3):

$$S1 = A\sin(2\pi t/T + P - \varepsilon(T)) \qquad ...(2)$$

$$S2 = A\sin(2\pi t/T + P - \varepsilon(T) - \pi/2) \qquad ...(3)$$

[0021]   The phase-shifted signal S1 has a phase delay of $\varepsilon(T)$ and the phase-shifted signal S2 has a phase delay of $\varepsilon(T) + \pi/2$. The above-described two all pass filters may employ primary 180° phase shifters. In this case, even if the period T of the AC signal S fluctuates about 10%, the phase difference between the two signals S1 and S2 can be maintained at 90° with a high precision.

[0022]   The present invention utilizes the following fact with respect to the phase-shifted signals S1 and S2 obtained as the equations (2) and (3). Namely, the phase angle of the signal S2, $2\pi t/T + P - \varepsilon(T) - \pi/2$, may become equal at a certain timing to a certain value, $m\pi + a$ (m denotes a positive integer). At this timing, the phase-shifted signals Si and S2 are represented independent of the period T and the phase P by the following equations (4) and (5) :

$$S1 = A\sin(\pi/2 + a) \qquad ..(4)$$

$$S2 = A\sin(a) \qquad ..(5)$$

[0023]   If the phase-shifted signal S1 is sampled at a timing when the phase-shifted signal S2 has the above phase angle, the sampled value becomes like the signal S1 represented by the equation (4), from which the amplitude A can be immediately derived if the value of a is known. The amplitude value thus obtained does not depend on the period T as well as the phase P.

[0024]   In particular, if a = 0, then the sampling point comes to a point with zero

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amplitude (zero cross point) of the phase-shifted signal S2. Therefore, when a zero cross point on the phase-shifted signal S2 is detected to generate a sampling pulse, which is employed to sample the phase-shifted signal S1, amplitude detection can be achieved without affection of the period fluctuations.

[0025]   Fig. 1 shows an amplitude-detecting circuit arrangement according to an embodiment of the present invention. An alternating signal S is an object to detect its amplitude. For example, it is a detected signal from an instrumental sensor such as a touch signal probe. The alternating signal S is a sine wave having a period fluctuation within a certain fluctuant range together with an amplitude fluctuation. A phase revising circuit 1 is provided to generate from the AC signal S two phase-shifted signals S1 and S2 with a phase difference of 90° from each other as indicated by the equations (2) and (3) . The phase revising circuit 1 includes two all pass filters 11 and 12, of which input terminals are commonly connected.

[0026]   The all pass filters 11, 12 are well-known primary phase shifters that have circuitry as shown in Fig. 2. The all pass filters 11, 12 configure 180° phase shifters that make a phase delay of 90° each at center frequencies f1, f2 by respectively setting of time constants, (Rx1 , Cx1), (Rx2, Cx2). Fig. 3 shows the phase-shift characteristics. Waveforms passing through the all pass filters 11, 12 do not vary their amplitude within the whole frequency range and only exhibit simple phase delays in response to frequencies.

[0027]   The AC signal S has a fundamental period of T and a fluctuant range of the period, between Tv and Tu. In a frequency range, w = 2p/Tv to 2p/Tu, corresponding to the fluctuant range of the period, the signals S1 and S2 respectively have phase delays of $\varepsilon(T)$ and $\varepsilon(T) + \pi/2$. These phase delays has a

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difference of $\pi/2$ therebetween, which is constant if the frequency fluctuant range, w = 2p/Tv to 2p/Tu, is contained between the center frequencies f1 and f2 of the two all pass filters 11 and 12. Namely, two accurately phase-shifted signals S1, S2 with a phase difference of just 90° can be obtained within the frequency fluctuant range.

[0028] For the two phase-shifted signals S1, S2 output from the all pass filters 11, 12, a sampling circuit 2 is provided to sample one of them, S1, at a timing when the other of them, S2, has a certain phase angle. Specifically in this embodiment, to generate a sampling pulse Sp based on the signal S2, a pulse generator 22 is provided to detect a zero cross point at which the signal S2 has zero amplitude. In addition, a full-wave rectifier 21 is employed to rectify the signal S1. The rectified output |S1| is supplied to the sampling circuit 2. Thus, amplitude peak values on each half-wave of the rectified output |S1| are sampled.

[0029] Fig. 4 shows waveforms on various nodes in Fig. 1. The sampling pulses Sp are generated at zero cross timings of the signal S2, tm (m = 1, 2, 3...) , as indicated with each arrow. As shown, the sampling period varies in response to the period fluctuation of the signal S. Thus, each sampling pulse Sp is generated at each amplitude peak position of the signal S. As a result, the amplitude peak value A(tm) of the rectified output |S1|, that is, the amplitude A of the signal S1 at the point, a = 0, in the equation (4) can be sampled.

[0030] The AC signal S has fluctuant period and amplitude. Fig. 4 shows waveforms with amplitude on the vertical axis and time on the horizontal axis. It can be found from Fig. 4 that the signals S1, S2 passed through the all pass filters 11, 12 are analogous to the original AC signal S but are not simply translated and rather distorted actually. Nevertheless, the relation shown in Fig. 3 can be satisfied. The

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phase delays, $\varepsilon(T)$ and $\varepsilon(T) + \pi/2$, indicated in Fig. 4 are converted values on the time axis.

[0031]   In the embodiment described above, in contrast to the conventional constant-period sampling method, the sampling is performed at a variable time interval in response to the jitter on the period of the signal subjected to amplitude-detection. As a result, a time-to-time variable amplitude of an alternating signal that has a jitter on a period can be detected accurately with a simple processing circuit. A slight time delay is present in the amplitude-detection as obvious from Fig. 4. Therefore, the method is applicable without any problems to a control system for real-time feedback controlling of an amplitude value.

[0032]   Fig. 5 shows another embodiment developed from the embodiment in Fig. 1. This embodiment provides a plurality of amplitude-detecting units U1, U2, ..., Un in parallel (n denotes a positive integer), each including the whole amplitude-detecting circuit arrangement shown in Fig. 1.

[0033]   These amplitude-detecting units are designed to have such relations that phase-shifted signals S1 output from the all pass filters 11 in the respective amplitude-detecting units have phase difference by 2π (=360°)/n from each other. Similarly, the phase-shifted signals S2 output from the all pass filters 12 in the respective amplitude-detecting units have phase difference by $2\pi/n$ from each other.

[0034]   As a result, in the amplitude-detecting units U1, U2, ..., Un, n amplitude values A1, A2, ...,An are sampled within each period of the original AC signal S. Therefore, compared to the use of a single amplitude-detecting unit, amplitude values are sampled at 1/n sampling interval. When this arrangement is applied to the real-time feedback control system, a fast and high accurate amplitude-control can be

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achieved.

[0035]   The circuit arrangements shown in Fig. 1 and Fig. 5 may be realized not only by analogue circuit simply but also by digital circuits easily. The AC signal S is A/D converted into digital data. Using a DSP (Digital Signal Processor) for all pass filtering and subsequent circuit processing, an amplitude value A(tm) may be converted into digital value to output.

[0036]   The present invention may be applied widely to other uses than the ultrasonic driven touch signal probe described above. For example, it may be applied to various instrumental sensors such as a micro-hole instrumental probe for providing a similar amplitude-modulated signal and an electrostatic capacitance gap sensor. It may also be applied to the use that requires extraction of variable amplitude values of an AC carrier with a swaying period such as wavelength control for a laser source.

[0037]   As obvious from the forgoing, according to the present invention, an alternating signal subjected to amplitude-detection is passed through two all pass filters to obtain two phase-shifted signals with a high precise phase difference of 90°. Then, one of the phase-shifted signals is sampled at timing when the other has a certain phase value, thereby detecting an amplitude value without affected from jitters on periods of the alternating signal.

[0038]   Having described the embodiments consistent with the invention, other embodiments and variations consistent with the invention will be apparent to those skilled in the art. Therefore, the invention should not be viewed as limited to the disclosed embodiments but rather should be viewed as limited only by the spirit and scope of the appended claims.